Appendix H

Transportation Impact Analysis

H1.0 Introduction

This appendix summarizes the methods and results of analyses for determining the environmental impacts of shipping uranium mill tailings and borrow materials by truck and rail. The impacts are presented by alternative and include doses and health effects.

The transportation impacts of shipping contaminated materials from vicinity properties, mill tailings from the Moab site, and borrow material from the proposed borrow areas would be from two sources: radiological impacts and nonradiological impacts. Radiological impacts would be from incident-free transportation and from transportation accidents that released contaminated material or uranium mill tailings. There would be no radiological impacts from moving borrow material because it is not contaminated. Nonradiological impacts would be from the engine and fugitive dust emissions from the truck or train moving the contaminated material, uranium mill tailings, and the borrow material, and from fatalities from traffic accidents during the transport of these materials. The total transportation impacts would be the sum of the radiological and nonradiological impacts.

H1.1 Incident-Free Transportation Impacts

Radiological dose during normal, incident-free transportation of contaminated material or uranium mill tailings would result from exposure to the external radiation field that surrounds the truck or rail car containing the contaminated material or uranium mill tailings. The dose is a function of the number of people exposed, their proximity to the containers, their length of time of exposure, and the intensity of the radiation field surrounding the truck or rail car.

Radiological impacts were determined for workers and the general population during normal, incident-free transportation. For truck shipments, the workers were drivers of the trucks carrying the contaminated material or uranium mill tailings. The radiation dose rate for the driver of a truck carrying contaminated material from vicinity properties was estimated to be 0.13 millirem (mrem) per hour using the MICROSHIELD computer code (Grove Engineering 1996). The radiation dose rate for the driver of a truck carrying uranium mill tailings from the Moab site was estimated to be 0.22 mrem per hour. For rail shipments, the workers would be individuals who inspected the train carrying the uranium mill tailings. The radiation dose rate for the inspectors was estimated to be 0.44 mrem per hour.

For truck shipments, the general population consisted of those individuals within 2,625 feet (ft) of the road (off-link) and individuals sharing the road (on-link). Because the trucks would drive directly to the disposal sites, no individuals were assumed to be exposed at stops. For rail shipments, the general population consisted of those individuals within 2,625 ft of the road (off-link). Because the train would not share the track with other trains at the same time and would not be in a classification yard, no individuals were assumed to be exposed at stops or on-link. Radiation doses for the general population were calculated using the RADTRAN 5 computer code (Neuhauser and Kanipe 2000, Neuhauser et al. 2000). The radiation dose rate for the vicinity property truck was estimated to be 0.17 mrem per hour at 3 ft from the truck. For the truck carrying uranium mill tailings, the radiation dose rate was estimated to be 0.30 mrem per hour. The radiation dose rate for the rail cars was estimated to be 0.44 mrem per hour at 3 ft from a rail car.

H1.1.1 Incident-Free Collective Dose Scenarios

Calculating the collective doses is based on developing unit risk factors. Unit risk factors provide an estimate of the impact from transporting one shipment of radioactive material over a unit distance of travel in a given population density zone. The unit risk factors may be combined with routing information such as the shipment distances in various population density zones to estimate the risk for a single shipment (a shipment risk factor) between a given origin and destination. Cashwell et al. (1986) contains a detailed explanation of the use of unit risk factors. Table H–1 contains the unit risk factors for truck and rail shipments.

Table H–1. Incident-Free Unit Risk Factors

Receptor	Zone	Truck	Rail
General population (public)			
Vicinity property off-link (person-rem/km per persons/km^2)	Rural	1.92E-09	0
	Suburban	1.92E-09	0
	Urban	1.92E-09	0
Vicinity property on-link (person-rem/km)	Rural	9.11E-07	0
	Suburban	9.11E-07	0
	Urban	9.11E-07	0
Off-link (person-rem/km per persons/km^2)	Rural	1.85E-09	4.42E-09
	Suburban	6.38E-09	4.42E-09
	Urban	6.38E-09	4.42E-09
On-link (person-rem/km)	Rural	1.65E-07	0
	Suburban	4.56E-07	0
	Urban	2.14E-06	0
Workers			
Vicinity property truck drivers (person-rem/km)	Rural	3.34E-06	0
	Suburban	3.34E-06	0
	Urban	3.34E-06	0
Mill tailings truck drivers (person-rem/km)	Rural	2.50E-06	0
	Suburban	3.93E-06	0
	Urban	3.93E-06	0
Rail inspector (person-rem/shipment)	Rural	0	7.99E-04
	Suburban	0	7.99E-04
	Urban	0	7.99E-04

km = kilometer

Incident-free nonradiological fatalities (pollution health effects) were also evaluated using unit risk factors. These fatalities would result from exhaust and fugitive dust emissions from highway and rail traffic and are associated with 10-micrometer (µm) particles. The nonradiological unit risk factor for truck transport used in this analysis was 1.5×10^{-11} fatalities per kilometer per persons per square kilometer; for train transport, the nonradiological unit risk factor was 2.6×10^{-11} fatalities per kilometer per persons per square kilometer. These unit risk factors were estimated from the data in Biwer and Butler (1999) and have been adjusted to account for more current diesel exhaust emission factors, a fleet average fugitive dust emission factor for roads, an age-adjusted mortality rate, and an average 10-µm particle risk factor. The distances used in the nonradiological analyses were doubled to reflect the round-trip distances, because these impacts could occur whether or not the shipments contain radioactive material. In addition, the impacts from pollution health effects included shipments from borrow areas.

H1.1.2 Incident-Free Maximally Exposed Individual Exposure Scenarios

Maximum individual doses were calculated using the RISKIND computer code (Yuan et al. 1995). The maximum individual doses for the routine transport off-site were estimated for transportation workers and for members of the public. For truck shipments, two scenarios were evaluated for members of the public:

- A person caught in traffic next to a truck containing uranium mill tailings for 30 minutes. The distance between the two vehicles was assumed to be 3 ft.
- A resident living 98 ft from the highway used to transport the uranium mill tailings. For shipments from vicinity properties, the resident lived 26 ft from the road. This person was assumed to be exposed to all shipments over the course of a year.

For rail shipments, two scenarios were evaluated for members of the public:

- A resident living 98 ft from the railroad used to transport the uranium mill tailings. This person was assumed to be exposed to all shipments over the course of a year.
- A person in a car stopped at a railroad crossing while a 30-car train passes. This person was assumed to be 9 ft from the train.

For truck shipments of uranium mill tailings, the maximally exposed worker would be the driver, who would be exposed for 1,000 hours per year. The radiation dose rate for the driver was estimated to be 0.22 mrem per hour, or 0.13 mrem per hour for a vicinity property truck driver. For rail shipments, the maximally exposed worker would be an individual who inspected the loaded rail cars for 1,000 hours per year. This individual would be 3 ft from a railcar, and the radiation dose rate for this individual was estimated to be 0.44 mrem per hour. The inspector would inspect rail cars prior to departure from the Moab site or after arrival at the disposal site.

H2.0 Transportation Accident Impacts

The transportation accident analysis considers the impacts of accidents during the transportation of uranium mill tailings and contaminated material by truck or rail. Under accident conditions, impacts to human health and the environment may result from the release and dispersal of radioactive material. Transportation accident impacts have been assessed using accident analysis methods developed by the U.S. Nuclear Regulatory Commission (NRC 1977). In addition, the nonradiological impacts from transportation accidents involving traffic fatalities were evaluated.

Two types of analyses were performed for accidents involving the dispersal of uranium mill tailings and contaminated material. First, an accident risk assessment was performed that takes into account the probabilities and consequences of a spectrum of potential accident severities. For the spectrum of accidents considered in the analysis, accident consequences in terms of collective dose to the population within 50 miles were multiplied by the accident probabilities to yield collective dose risk using the RADTRAN 5 computer code (Neuhauser and Kanipe 2000, Neuhauser et al. 2000).

Second, to represent the maximum reasonably foreseeable impacts to individuals and populations should an accident occur, radiological consequences were calculated for an accident of maximum credible severity. An accident is considered credible if its probability of occurrence is greater than 1×10^{-7} per year (1 in 10 million per year). The accident consequence assessment for maximally exposed individuals and population groups was performed using the RISKIND computer code (Yuan et al. 1995).

The radiological impacts were calculated in units of dose (rem or person-rem). Impacts are further expressed as health risks in terms of estimated latent cancer fatalities in exposed populations.

H2.1 Transportation Accident Rates

Utah-specific accident rates and fatality rates taken from data provided in Saricks and Tompkins (1999) for rail and heavy combination trucks were used to estimate accident risks and consequences, and traffic fatalities. These rates are presented in Table H–2.

Table H–2. Utah-Specific Accident and Fatality Rates

Type	Mode	Accident Rate	Fatality Rate
State Highway	Truck	3.05×10^{-7} accidents/km	1.60×10^{-8} fatalities/km
Interstate	Truck	2.90×10^{-7} accidents/km	1.19×10^{-8} fatalities/km
Other	Truck	9.04×10^{-7} accidents/km	2.27×10^{-8} fatalities/km
Rail	Rail	5.87×10^{-8} accidents/railcar-km	2.54×10^{-8} fatalities/railcar-km

H2.1.1 Severity Categories, Conditional Probabilities, and Release Fractions

Transportation accidents have different severities and would result in the release of different amounts of uranium mill tailings or contaminated materials. Therefore, accidents are grouped into severity categories. Each severity category has a different conditional probability of occurrence and release fraction. In this analysis, the release fraction is the fraction of material released that is respirable. The respirable release fractions considered the large particle size of uranium mill tailings (45 to 75 µm for slimes and 75 to 500 µm for sands), with 10 µm as the upper bound for a respirable particle. The severity categories, conditional probabilities, and release fractions for truck and rail accidents are presented in Tables H–3 and H−4, respectively.

Table H–3. Severity Categories, Conditional Probabilities, and Respirable Release Fractions for Truck Accidents

Severity Category	Conditional Probability	Respirable Release Fraction
1	0.80	0.0
2	0.10	5.0×10^{-6}
3	0.05	2.5×10^{-5}
4	0.05	5.0×10^{-5}

Table H–4. Severity Categories, Conditional Probabilities, and Respirable Release Fractions for Rail Accidents

Severity Category	Conditional Probability	Respirable Release Fraction
1	0.60	0.0
2	0.20	5.0×10^{-6}
3	0.20	5.0×10^{-5}

H2.1.2 Shipment Inventories

Based on data from the Moab site, the average radium-226 (Ra-226) concentration in the uranium mill tailings was 516 picocuries per gram (pCi/g), and the density of the tailings was 1.6 grams per cubic centimeter (cm^3). In order to calculate the radionuclide inventory contained in a truck or train, it was assumed that Ra-226 was in secular equilibrium with its radioactive progeny. In addition, thorium-230 (Th-230) was assumed to be present in equilibrium with Ra-226. A 44-ton tandem truck was assumed to be used for truck shipments of uranium mill tailings. A 10-cubic-yard (yd^3) truck was assumed to be used for shipments from vicinity properties. A 100-ton gondola car was assumed to be used for rail shipments of uranium mill tailings. Table H–5 shows the estimated radionuclide inventories for truck and rail shipments.

Table H–5. Radionuclide Inventory in Uranium Mill Tailings Shipments

Radionuclide	Concentration (pCi/g)	Truck Inventory (Ci)	Railcar Inventory (Ci)	Vicinity Property Truck Inventory (Ci)
Th-230	516.00	0.021	0.047	0.0063
Ra-226	516.00	0.021	0.047	0.0063
Radon-222 (Rn-222)[a]	516.00	0.021	0.047	0.0063
Polonium-218 (Po-218)	516.00	0.021	0.047	0.0063
Lead-214 (Pb-214)	515.90	0.021	0.047	0.0063
Bismuth-214 (Bi-214)	516.00	0.021	0.047	0.0063
Polonium-214 (Po-214)	515.89	0.021	0.047	0.0063
Lead-210 (Pb-210)	516.00	0.021	0.047	0.0063
Bismuth-210 (Bi-210)	516.00	0.021	0.047	0.0063
Polonium-210 (Po-210)	516.00	0.021	0.047	0.0063

[a]Rn-222 through Po-210 are radioactive progeny of Ra-226.
Ci = curies; pCi/g = picocuries per gram.

H2.1.3 Atmospheric Conditions

Because it is impossible to predict the specific location of a transportation accident, generic atmospheric conditions were selected for the risk and consequence assessments. For the accident risk assessment, neutral weather conditions (Pasquill Stability Class D) were assumed. Neutral weather conditions are typified by moderate wind speeds, vertical mixing within the atmosphere, and good dispersion of atmospheric contaminants. For the accident consequence assessment, doses were assessed under neutral (Class D with 14.67-ft-per-second wind speed) atmospheric conditions.

H2.1.4 Exposure Pathways

Radiological doses were calculated for an individual located near the scene of the accident and for populations within 50 miles of the accident. Rural, suburban, and urban population densities were assessed. Dose calculations considered a variety of exposure pathways, including inhalation and direct exposure from the passing cloud (cloudshine), direct exposure from radioactivity deposited on the ground (groundshine), and inhalation of resuspended radioactive particles from the ground.

H2.1.5 Health Risk Conversion Factors

The following health risk conversion factors used to estimate latent cancer fatalities from radiological exposures were from the Interagency Steering Committee on Radiation Standards (DOE 2002): 6×10^{-4} and 5×10^{-4} latent cancer fatalities per person-rem for members of the public and workers, respectively. Although latent cancer fatalities are the predominant health risk associated with low-level radiation doses (that is, doses below the thresholds for acute effects), they are not the only potential detrimental health effect. Risks of other delayed health effects such as nonfatal cancers and hereditary effects should also be acknowledged. International Commission on Radiological Protection Publication 60 (ICRP 1991) has estimated that the total risk of detrimental health effects are 7.3×10^{-4} and 5.6×10^{-4} total detrimental health effects per person-rem for members of the public and workers, respectively.

H3.0 Shipments

For each alternative, there would be shipments of contaminated material from vicinity properties, uranium mill tailings, and borrow material. The borrow material would consist of cover soils, radon barrier soils, sand and gravel, riprap, and Moab site reclamation soils. The numbers of shipments are listed for each alternative in Tables H−6 through H−9. The distances for the shipments are listed in Table H–10.

Table H–6. Number of Shipments for the On-Site Disposal Alternative

Material	Truck Shipments
Vicinity property material	2,940
Borrow material	
Cover soils[a]	25,030
Radon barrier soils[b]	11,200
Sand and gravel[c]	4,200
Riprap[d]	6,363
Moab site reclamation soils[a]	9,670
Total	**59,403**

[a]Cover soils and reclamation soils were assumed to be from the Floy Wash borrow area.
[b]Radon barrier soils were assumed to be from the Klondike Flats borrow area.
[c]Sand and gravel was assumed to be from the LeGrand Johnson borrow area.
[d]Riprap was assumed to be from the Papoose Quarry borrow area.

Table H–7. Shipments for Klondike Flats Disposal Alternative

Material	Truck Option		Rail Option		Slurry Pipeline Option	
	Shipments	Mode	Shipments	Mode	Shipments	Mode
Vicinity property material	2,940	Truck	2,940	Truck	2,940	Truck
Borrow material						
Cover soils[a]	37,800	Truck	37,800	Truck	37,800	Truck
Radon barrier soils[b]	0		0		0	Truck
Sand and gravel[c]	6,538	Truck	6,538	Truck	6,538	Truck
Riprap[d]	1,973	Truck	1,973	Truck	1,973	Truck
Moab site reclamation soils[a]	12,875	Truck	12,875	Truck	12,875	Truck
Uranium mill tailings	268,800	Truck	3,840 2,188	Rail[e] Truck	2,188	Truck
Total	**330,926**		**68,154**		**64,314**	

[a]Cover soils and reclamation soils were assumed to be from the Floy Wash borrow area.
[b]Radon barrier soils were assumed to be from the Klondike Flats borrow area.
[c]Sand and gravel was assumed to be from the LeGrand Johnson borrow area.
[d]Riprap was assumed to be from the Papoose Quarry borrow area.
[e]Each rail shipment would consist of 30 rail cars of uranium mill tailings.

Table H–8. Shipments for Crescent Junction Disposal Alternative

Material	Truck Option		Rail Option		Slurry Pipeline Option	
	Shipments	Mode	Shipments	Mode	Shipments	Mode
Vicinity property material	2,940	Truck	2,940	Truck	2,940	Truck
Borrow material						
Cover soils[a]	0		0		0	
Radon barrier soils[a]	0		0		0	
Sand and gravel[b]	6,300	Truck	6,300	Truck	6,300	Truck
Riprap[c]	1,973	Truck	1,973	Truck	1,973	Truck
Moab site reclamation soils[d]	12,875	Truck	12,875	Truck	12,875	Truck
Uranium mill tailings	268,800	Truck	3,840 2,188	Rail[e] Truck	2,188	Truck
Total	**292,888**		**30,116**		**26,276**	

[a]Cover soils and radon barrier soils were assumed to be from the Crescent Junction borrow area.
[b]Sand and gravel was assumed to be from the LeGrand Johnson borrow area.
[c]Riprap was assumed to be from the Papoose Quarry borrow area.
[d]Reclamation soils were assumed to be from the Floy Wash borrow area.
[e]Each rail shipment would consist of 30 rail cars of uranium mill tailings.

Table H–9. Shipments for White Mesa Mill Disposal Alternative

Material	Truck Option		Slurry Pipeline Option	
	Shipments	**Mode**	**Shipments**	**Mode**
Vicinity property material	2,940	Truck	2,940	Truck
Borrow material				
Cover soils[a]	0		0	
Radon barrier soils[a]	0		0	
Sand and gravel[b]	6,300	Truck	6,300	Truck
Riprap[c]	1,973	Truck	1,973	Truck
Moab site reclamation soils[d]	12,875	Truck	12,875	Truck
Uranium mill tailings	268,800	Truck	2,188	Truck
Total	**292,888**		**26,276**	

[a]Cover soils and radon barrier soils were assumed to be from the White Mesa borrow area.
[b]Sand and gravel was assumed to be from the LeGrand Johnson borrow area.
[c]Riprap was assumed to be from the Papoose Quarry borrow area.
[d]Reclamation soils were assumed to be from Floy Wash borrow area.

Table H–10. Shipment Distances

Origin	Destination	Truck Distance (miles)[a]	Rail Distance (miles)[a]
Vicinity Properties	Moab	5.0	N/A
Moab	Klondike Flats	19	16
Moab	Crescent Junction	31	30
Moab	White Mesa Mill	85	N/A
Floy Wash borrow area	Moab	35	N/A
Klondike Flats borrow area	Moab	18	N/A
LeGrand Johnson borrow area	Moab	6.0	N/A
Papoose Quarry borrow area	Moab	28	N/A
Floy Wash borrow area	Klondike Flats	25	N/A
LeGrand Johnson borrow area	Klondike Flats	24	N/A
Papoose Quarry borrow area	Klondike Flats	53	N/A
LeGrand Johnson borrow area	Crescent Junction	39	N/A
Papoose Quarry borrow area	Crescent Junction	68	N/A
LeGrand Johnson borrow area	White Mesa Mill	91	N/A
Papoose Quarry borrow area	White Mesa Mill	10	N/A

[a]All distances are one-way distances.

H4.0 Results

H4.1 Transportation Impacts

H4.1.1 On-Site Disposal Alternative

Table H–11 lists the transportation impacts for the on-site disposal alternative. The transportation impacts would be from shipping contaminated materials from vicinity properties to the Moab site and shipping borrow materials. Borrow materials would consist of cover soils and reclamation soils shipped from the Floy Wash borrow area, radon barrier soils shipped from the Klondike Flats borrow area, sand and gravel shipped from the LeGrand Johnson borrow area, and riprap shipped from the Papoose Quarry borrow area. For this alternative, there would less than one fatality.

Table H–11. Transportation Impacts for the On-Site Disposal Alternative

Alternative	Radiological			Nonradiological		Total Fatalities
	Incident-Free		Accident Risk	Pollution Health Effects Fatalities	Traffic Fatalities	
	Public LCFs	Worker LCFs				
Truck option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	1.1E-3	8.1E-2	8.2E-2
Mill tailings	0	0	0	0	0	0
Total	2.7E-5	3.9E-5	6.9E-9	1.5E-3	8.2E-2	8.4E-2

LCFs = latent cancer fatalities

H4.1.2 Klondike Flats Off-Site Disposal Alternative

Table H–12 lists the transportation impacts for the Klondike Flats off-site disposal alternative. Transportation impacts would be from shipping contaminated materials from vicinity properties to the Moab site, shipping uranium mill tailings and vicinity property material from the Moab site to Klondike Flats, and shipping borrow materials. Borrow materials would consist of cover soils shipped from the Floy Wash borrow area to Klondike Flats, reclamation soils shipped from the Floy Wash borrow area to the Moab site, sand and gravel shipped from the LeGrand Johnson borrow area to Klondike Flats, and riprap shipped from Papoose Quarry borrow area to Klondike Flats. For this alternative, there would less than one fatality.

Table H–12. Transportation Impacts for the Klondike Flats Off-Site Disposal Alternative

Alternative	Radiological			Nonradiological		Total Fatalities
	Incident-Free		Accident Risk	Pollution Health Effects Fatalities	Traffic Fatalities	
	Public LCFs	Worker LCFs				
Truck option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	9.3E-4	8.1E-2	8.2E-2
Mill tailings	1.6E-3	1.0E-2	2.0E-9	9.6E-5	2.6E-1	2.7E-1
Total	1.6E-3	1.0E-2	8.9E-9	1.4E-3	3.4E-1	3.5E-1
Rail option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	9.3E-4	8.1E-2	8.2E-2
Mill tailings	1.6E-5	1.6E-3	3.5E-9	6.1E-5	1.5E-1	1.5E-1
Total	4.3E-5	1.6E-3	1.0E-8	1.4E-3	2.3E-1	2.3E-1
Slurry option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	9.3E-4	8.1E-2	8.2E-2
Mill tailings	1.3E-5	8.4E-5	1.6E-11	7.8E-7	2.1E-3	2.2E-3
Total	4.0E-5	1.2E-4	6.9E-9	1.3E-3	8.4E-2	8.6E-2

LCFs = latent cancer fatalities

H4.1.3 Crescent Junction Off-Site Disposal Alternative

Table H–13 lists the transportation impacts for the Crescent Junction off-site disposal alternative. Transportation impacts would be from shipping contaminated materials from vicinity properties to the Moab site, shipping uranium mill tailings and vicinity property material from the Moab site to Crescent Junction, and shipping borrow materials. Borrow materials would consist of reclamation soils shipped from the Floy Wash borrow area to the Moab site, sand and gravel shipped from the LeGrand Johnson borrow area to Crescent Junction, and riprap shipped from the Papoose Quarry borrow area to Crescent Junction. For this alternative, there would less than one fatality.

Table H–13. Transportation Impacts for the Crescent Junction Off-Site Disposal Alternative

Alternative	Radiological			Nonradiological		Total Fatalities
	Incident-Free		Accident Risk	Pollution Health Effects Fatalities	Traffic Fatalities	
	Public LCFs	Worker LCFs				
Truck Option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	8.9E-4	4.2E-2	4.3E-2
Mill tailings	2.7E-3	1.7E-2	3.3E-9	1.6E-4	4.3E-1	4.5E-1
Total	2.7E-3	1.7E-2	1.0E-8	1.4E-3	4.7E-1	4.9E-1
Rail Option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	8.9E-4	4.2E-2	4.3E-2
Mill tailings	2.7E-5	1.7E-3	6.5E-9	1.1E-4	2.9E-1	2.9E-1
Total	5.4E-5	1.7E-3	1.3E-8	1.4E-3	3.3E-1	3.3E-1
Slurry Option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	8.9E-4	4.2E-2	4.3E-2
Mill tailings	2.2E-5	1.4E-4	2.7E-11	1.3E-6	3.5E-3	3.7E-3
Total	4.9E-5	1.8E-4	6.9E-9	1.3E-3	4.7E-2	4.8E-2

LCFs = latent cancer fatalities

H4.1.4 White Mesa Mill Off-Site Disposal Alternative

Table H–14 lists the transportation impacts for the White Mesa Mill off-site disposal alternative. Transportation impacts would be from shipping contaminated materials from vicinity properties to the Moab site, shipping uranium mill tailings and vicinity property material from the Moab site to White Mesa Mill, and shipping borrow materials. Borrow materials would consist of reclamation soils shipped from the Floy Wash borrow area to the Moab site, sand and gravel shipped from the LeGrand Johnson borrow area to White Mesa Mill, and riprap shipped from the Papoose Quarry borrow area to White Mesa Mill. For this alternative, there would be about one fatality.

Table H–14. Transportation Impacts for the White Mesa Mill Off-Site Disposal Alternative

Alternative	Radiological			Nonradiological		Total Fatalities
	Incident-Free		Accident Risk	Pollution Health Effects Fatalities	Traffic Fatalities	
	Public LCFs	Worker LCFs				
Truck option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	1.2E-3	5.3E-2	5.4E-2
Mill tailings	2.6E-2	4.9E-2	1.4E-6	6.7E-2	1.2E+0	1.3E+0
Total	2.6E-2	4.9E-2	1.4E-6	6.9E-2	1.3E+0	1.4E+0
Slurry option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	1.2E-3	5.3E-2	5.4E-2
Mill tailings	2.1E-4	4.0E-4	1.1E-8	5.4E-4	9.6E-3	1.1E-2
Total	2.4E-4	4.4E-4	1.8E-8	2.1E-3	6.4E-2	6.7E-2

LCFs = latent cancer fatalities

H4.2 Incident-Free Radiation Doses to Maximally Exposed Individuals

H4.2.1 On-Site Disposal Alternative

Table H–15 lists the incident-free radiation doses for the maximally exposed individual scenarios for the on-site disposal alternative. For truck shipments of contaminated materials from vicinity properties to the Moab site, the maximally exposed transportation worker would be the driver of the truck. This person would receive a radiation dose of 26 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 1.3×10^{-5}.

For truck shipments of contaminated materials from vicinity properties to the Moab site, the maximally exposed member of the public would be a person who happened to be stuck in a traffic jam next to a truck containing contaminated materials. This person would receive a radiation dose of 0.084 mrem, which is equivalent to a probability of a latent cancer fatality of about 5.0×10^{-8}.

H4.2.2 Klondike Flats Off-Site Disposal Alternative

Table H–15 lists the incident-free radiation doses for the maximally exposed individual scenarios for the Klondike Flats off-site disposal alternative. For truck shipments of mill tailings from Moab to Klondike Flats, the maximally exposed transportation worker would be the driver of the truck. This person was assumed to drive the truck containing mill tailings for 1,000 hours per year. For the other 1,000 hours per year, the truck would be empty. This driver would receive a radiation dose of 220 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 1.1×10^{-4}. This represents an upper bound to potential radiation impacts, because it includes no wait times, training times, etc.

For rail shipments of mill tailings from Moab to Klondike Flats, the maximally exposed transportation worker would be an individual who inspected the rail cars. This person would receive a radiation dose of 440 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 2.2×10^{-4}. This also represents an upper bound on potential radiation impacts, because it assumes that the individual inspects rail cars for 1,000 hours per year, and includes no wait times, training times, etc.

Table H–15. Incident-Free Radiation Doses for the Maximally Exposed Individual Scenarios

Scenario	On-Site Disposal	Klondike Flats Disposal	Crescent Junction Disposal	White Mesa Mill Disposal
Truck				
Nearby resident (member of the public)	0.0058 mrem/yr (3.5E-9 LCFs)	1.0 mrem/yr (6.3E-7 LCFs)	1.0 mrem/yr (6.3E-7 LCFs)	1.0 mrem/yr (6.3E-7 LCFs)
Individual in traffic jam (member of the public)	0.084 mrem/yr (5.0E-8 LCFs)	0.15 mrem/yr (9.0E-8 LCFs)	0.15 mrem/yr (9.0E-8 LCFs)	0.15 mrem/yr (9.0E-8 LCFs)
Driver (occupational)	26 mrem/yr (1.3E-5 LCFs)	220 mrem/yr (1.1E-4 LCFs)	220 mrem/yr (1.1E-4 LCFs)	220 mrem/yr (1.1E-4 LCFs)
Rail				
Nearby resident (member of the public)	N/A	0.53 mrem/yr (3.2E-7 LCFs)	0.53 mrem/yr (3.2E-7 LCFs)	N/A
Individual at railroad crossing (member of the public)	N/A	1.4E-6 mrem/yr (8.5E-13 LCFs)	1.4E-6 mrem/yr (8.5E-13 LCFs)	N/A
Inspector (occupational)	N/A	440 mrem/yr (2.2E-4 LCFs)	440 mrem/yr (2.2E-4 LCFs)	N/A

LCFs = latent cancer fatalities

For truck shipments of mill tailings from Moab to Klondike Flats, the maximally exposed member of the public would be a resident who lived along the road on which the tailings were shipped. This person would receive a radiation dose of 1.0 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 6.3×10^{-7}.

For rail shipments of mill tailings from Moab to Klondike Flats, the maximally exposed member of the public would also be a resident who lived along the rail line on which the tailings were shipped. This person would receive a radiation dose of 0.53 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 3.2×10^{-7}.

H4.2.3 Crescent Junction Off-Site Disposal Alternative

Table H–15 lists the incident-free radiation doses for the maximally exposed individual scenarios for the Crescent Junction off-site disposal alternative. For truck shipments of mill tailings from Moab to Crescent Junction, the maximally exposed transportation worker would be the driver of the truck. This person was assumed to drive the truck containing mill tailings for 1,000 hours per year. For the other 1,000 hours per year, the truck would be empty. This driver would receive a radiation dose of 220 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 1.1×10^{-4}. This represents an upper bound to potential radiation impacts, because it includes no wait times, training times, etc.

For rail shipments of mill tailings from Moab to Crescent Junction, the maximally exposed transportation worker would be an individual who inspected the rail cars. This person would receive a radiation dose of 440 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 2.2×10^{-4}. This also represents an upper bound on potential radiation impacts, because it assumes that the individual inspects rail cars for 1,000 hours per year, and includes no wait times, training times, etc.

For truck shipments of mill tailings from Moab to Crescent Junction, the maximally exposed member of the public would be a resident who lived along the road on which the tailings were shipped. This person would receive a radiation dose of 1.0 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 6.3×10^{-7}.

For rail shipments of mill tailings from Moab to Crescent Junction, the maximally exposed member of the public would also be a resident who lived along the rail line on which the tailings were shipped. This person would receive a radiation dose of 0.53 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 3.2×10^{-7}.

H4.2.4 White Mesa Mill Off-Site Disposal Alternative

Table H–15 lists the incident-free radiation doses for the maximally exposed individual scenarios for the White Mesa Mill off-site disposal alternative. For truck shipments of mill tailings from Moab to White Mesa Mill, the maximally exposed transportation worker would be the driver of the truck. This person was assumed to drive the truck containing mill tailings for 1,000 hours per year. For the other 1,000 hours per year, the truck would be empty. This driver would receive a radiation dose of 220 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 1.1×10^{-4}. This represents an upper bound to potential radiation impacts, because it includes no wait times, training times, etc.

For truck shipments of mill tailings from Moab to White Mesa Mill, the maximally exposed member of the public would be a resident who lived along the road on which the tailings were shipped. This person would receive a radiation dose of 1.0 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 6.3×10^{-7}.

H4.3 Impacts from Severe Transportation Accidents

In addition to analyzing the radiological and nonradiological risks of transporting contaminated material from vicinity properties, shipping uranium mill tailings and vicinity property material from the Moab site, and shipping borrow materials, DOE assessed the consequences of severe transportation accidents, known as maximum reasonably foreseeable transportation accidents. These severe accidents have a probability of about 1×10^{-7} per year. The consequences of these accidents were determined through the inhalation, groundshine, and immersion pathways.

The following assumptions were used to estimate the consequences of maximum reasonably foreseeable accidents:

- The release height of the plume is 3.3 ft.
- The breathing rate for individuals is assumed to be 10,500 yd^3 per year.
- The short-term exposure to airborne contaminants is assumed to be 2 hours.
- The long-term exposure to contamination deposited on the ground is assumed to be 1 year for the maximally exposed individual and the population, with no interdiction or cleanup.
- The accident was assumed to occur in either a rural area or near Moab, Monticello, or Blanding.
- Impacts were determined using moderate wind speeds and neutral atmospheric conditions (a wind speed of 14.67 ft per second and Class D stability).
- The release fractions used in the analysis were for Severity Category 4 truck accidents or Severity Category 3 rail accidents (see Tables H−3 and H−4).
- The shipment inventories used in the analysis are listed in Table H–5.

H4.3.1 On-Site Disposal Alternative

The maximally exposed individual would receive a radiation dose of 4.8×10^{-5} rem from the maximum reasonably foreseeable transportation accident involving a shipment of mill tailings from a vicinity property to the Moab site. This is equivalent to a probability of a latent cancer fatality of about 2.9×10^{-8}. The probability of this accident is about 4×10^{-4} per year. The population would receive a collective radiation dose of 5.6×10^{-4} person-rem from this accident, which is equivalent to a probability of a latent cancer fatality of about 3.3×10^{-7}.

H4.3.2 Klondike Flats Off-Site Disposal Alternative

If trucks were used to transport the mill tailings from Moab to Klondike Flats, the maximally exposed individual would receive a radiation dose of 1.6×10^{-4} rem from the maximum reasonably foreseeable transportation accident involving a shipment of mill tailings, which is equivalent to a probability of a latent cancer fatality of about 9.6×10^{-8}. The probability of this accident is about 0.06 per year.

If this accident occurred near Moab, the population would receive a collective radiation dose of 0.0018 person-rem. This is equivalent to a probability of a latent cancer fatality of about 1.1×10^{-6}. If this accident occurred in a rural area, the population would receive a collective radiation dose of 2.9×10^{-6} person-rem, which is equivalent to a probability of a latent cancer fatality of about 1.7×10^{-9}.

If rail were used to transport the mill tailings from Moab to Klondike Flats, the maximally exposed individual would receive a radiation dose of 0.0014 rem from the maximum reasonably foreseeable transportation accident involving a shipment of mill tailings, which is equivalent to a probability of a latent cancer fatality of about 8.5×10^{-7}. The probability of this accident is about 0.3 per year.

If this accident occurred near Moab, the population would receive a collective radiation dose of 0.017 person-rem. This is equivalent to a probability of a latent cancer fatality of about 1.0×10^{-5}. If this accident occurred in a rural area, the population would receive a collective radiation dose of 2.7×10^{-5} person-rem, which is equivalent to a probability of a latent cancer fatality of about 1.6×10^{-8}.

H4.3.3 Crescent Junction Off-Site Disposal Alternative

If trucks were used to transport the mill tailings from Moab to Crescent Junction, the maximally exposed individual would receive a radiation dose of 1.6×10^{-4} rem from the maximum reasonably foreseeable transportation accident involving a shipment of mill tailings, which is equivalent to a probability of a latent cancer fatality of about 9.6×10^{-8}. The probability of this accident is about 0.1 per year.

If this accident occurred near Moab, the population would receive a collective radiation dose of 0.0018 person-rem. This is equivalent to a probability of a latent cancer fatality of about 1.1×10^{-6}. If this accident occurred in a rural area, the population would receive a collective radiation dose of 2.9×10^{-6} person-rem, which is equivalent to a probability of a latent cancer fatality of about 1.7×10^{-9}.

If rail were used to transport the mill tailings from Moab to Crescent Junction, the maximally exposed individual would receive a radiation dose of 0.0014 rem from the maximum reasonably foreseeable transportation accident involving a shipment of mill tailings, which is equivalent to a probability of a latent cancer fatality of about 8.5×10^{-7}. The probability of this accident is about 0.5 per year.

If this accident occurred near Moab, the population would receive a collective radiation dose of 0.017 person-rem. This is equivalent to a probability of a latent cancer fatality of about 1.0×10^{-5}. If this accident occurred in a rural area, the population would receive a collective radiation dose of 2.7×10^{-5} person-rem, which is equivalent to a probability of a latent cancer fatality of about 1.6×10^{-8}.

H4.3.4 White Mesa Mill Off-Site Disposal Alternative

If trucks were used to transport the mill tailings from Moab to White Mesa Mill, the maximally exposed individual would receive a radiation dose of 1.6×10^{-4} rem from the maximum reasonably foreseeable transportation accident involving a shipment of mill tailings, which is equivalent to a probability of a latent cancer fatality of about 9.6×10^{-8}. The probability of this accident is about 0.3 per year.

If this accident occurred near Moab, Monticello, or Blanding, the population would receive a collective radiation dose of 0.0018 person-rem, which is equivalent to a probability of a latent cancer fatality of about 1.1×10^{-6}. If this accident occurred in a rural area, the population would receive a collective radiation dose of 2.9×10^{-6} person-rem. This is equivalent to a probability of a latent cancer fatality of about 1.7×10^{-9}.

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